REMARKS

Applicants appreciate the thorough review of the application and claims by the Examiner.

The specification is amended to correct typographical errors. These amendments are made for consistency within the nomenclature established in the specification, and are not made for patentability in response to the Examiner's prior art rejections. No new matter is believed to be added.

The specification is amended at pages 41 and 55 to improve the transition between paragraphs of the detailed description, and to remove redundant text therein; such changes should clarify the description of illuminant-neutral gray component replacement.

No new matter is believed to be added.

Claims 1-45 are cancelled. New claims 46-79 are added. Support for the new claims is found in the specification as noted in the following remarks.

General Discussion of the Embodiments

In the Specification under *"Introduction to a General Theory of the Invention"*, applicants introduce a basic concept that underlies the claimed embodiments of the invention:

> [0088] Embodiments of the present invention accordingly exploit the interaction between certain narrowband illuminants and their corresponding (complementary) colorants (especially the colorants typically used for printing), and the manner in which the eye detects images illuminated with illuminants having narrowband spectral power distributions. The methodology described herein may be generalized to apply to an arbitrary number of illuminants and colorants....

Some embodiments of the invention are summarized as:

> [0020] Accordingly, the present invention is directed to methods and apparatus for spectrally-encoding plural source images and for providing the spectrally-encoded plural source images in a composite image, for rendering the composite image in a physical form, or for recovering at least one of the encoded source images from the rendered composite image such that the recovered source image is made distinguishable. That is, when the rendered composite image is subjected to illumination by one of the narrow band illuminants for which a source image was encoded, the source image becomes visually detectable by an observer. An illuminant that is designed to particularly interact with a given colorant is said to be complementary, and vice versa.

As further defined in the specification, a first source image may be recovered primarily from the visual appearance of a pattern of the first colorant in a rendered composite image when that rendered composite image is illuminated by its complementary narrowband illuminant. Similarly, a second source image may be made visually distinguishable by viewing a pattern of second colorant while that rendered composite image is illuminated by the respective narrowband illuminant that is complementary to the second colorant. Accordingly, a source image encoded in a rendered composite image becomes more distinguishable to an observer when the field of illumination directed upon the rendered composite image changes from a broadband illuminant (such as daylight) to illumination by a specific (respectively complementary) narrowband illuminant. A source image is more easily distinguishable from the remainder of the image content of the rendered composite image, during the instance of illumination by the particular narrow band illuminant, because the apparent density of certain portions of the rendered composite image are greater than the apparent density of the remaining portions of the image and because human perception reduces to a unidimensional "lightness-darkness" axis under narrow band illumination. Thus, applicants describe an aspect of the basic methodology for the practice of the

invention, as follows:

> [00103] Accordingly, this methodology exploits the characteristically low density of a colorant when subjected to a first illuminant having a predefined spectral power distribution and the characteristically high density exhibited by the same colorant when subjected to a second illuminant having a differing spectral power distribution. Thus, at least one perceptibly distinct source image (that is encoded in the rendered composite image by use of the particular colorant), can be imperceptible (or nearly so) to an observer when subjected to the first illuminant, but perceptibly distinguishable to the observer when illuminated by the second illuminant. Upon perception of the source image by an observer, the source image may be comprehended and the information embedded in the composite image, or the composite image itself, is thereby readily comprehended..

Applicants have further distinguished the invention over the prior art in teaching that the composite image is to be encoded by performing spectral encoding of plural source images:

> [0021] A given source image is spectrally encoded by mapping values representative of each source image pixel to a corresponding pixel value in one or more of a plurality of colorant image planes. The composite image may be defined in a spectrally multiplexed (SM) image plane, which may have any number of different patterns of pixels, with a primary characteristic being that the SM image plane is spectrally multiplexed. In general, at each location in the SM image plane, a pixel value representing one or more spectral components may be present, and which spectral component is present depends on the gray level of the corresponding pixel in one of the separation image planes that described

the source image. Alternatively, the SM image planes may be spectrally multiplexed in which each pixel includes color values representative of color separation image data from more than one source image plane.

The mapping includes compensating determinations:

[0024] In another embodiment of the contemplated encoding, the mapping of each source image is performed according to determinations described herein for compensating the effect of one or more of the following on the composition, rendering, or demultiplexing of the composite image: (a) the trichromacy of human visual response to colorant/illuminant interaction; (b) the spectral characteristics of the colorants selected for rendering the composite image, such spectral characteristics especially comprehending the interaction of plural colorants when such are combined on the substrate, and (c) the spectral characteristics of the narrow-band illuminant(s) that will be used to illuminate the composite image for recovering the source image(s).

The spectral multiplexing thus affords the opportunity, during the mapping of each source image, for adjustments to the source image to compensate for certain phenomena, so as to enhance the recovery of a source image during demultiplexing.

With respect to those adjustments, Applicants have achieved a further inventive contribution by recognizing, as described above in (b), the effect of the interaction of plural colorants on an observer's perception of a recovered image, when such plural colorants are combined on a substrate. For example, a given colorant will naturally exhibit an unwanted absorption characteristic when illuminated by an illuminant other than the illuminant that is complementary to that colorant. Such unwanted absorption can cause visual artifacts to appear in the rendered composite image during demultiplexing, and thereby impair the

recovery of the desired source image. Applicants have taught that such unwanted absorption can be advantageously compensated to reduce their visibility. Applicants also teach, in para. 0115 et seq., a technique for maximizing the dynamic range between the recovered source image and the remaining image content of the rendered composite image, as described in the specification at, for example, para. 0104-0138.

Also with respect to the aforementioned adjustments, Applicants also teach, in para. 0177 et seq., that whereas a conventional GCR technique uses the common density of colorants under a single illuminant (typically ambient white light), a novel form of GCR is contemplated for the encoding and rendering of a composite image, which is described as "illuminant-neutral gray component replacement (GCR)." This novel form of GCR is discussed further, below, with respect to the claims.

New Claims

In the interest of expedited prosecution, applicants have clarified the operation of the encoding and mapping (which includes the above-described illuminant-neutral gray component replacement) as presented in the new claims, which incorporate aspects of these features. New claims 46-79 are now provided, wherein those features are more clearly set forth.

Rejections Under 35 USC 112

Applicants appreciate the thorough review of the claims by the Examiner. The bases for the section 112 rejections are believed to be rectified in the newly submitted claims.

Rejections Under 35 USC 102

Claims 1-9, 11-16, 18, 21-31, 33-45 were rejected as being anticipated by USP 6891959 ("Reed"). These claims are cancelled. New claims 46-79 are believed patentable for the following reasons.

The Examiner appears to have improperly applied the definition of "illuminant-neutral GCR" to the cited art in making the rejection. The following remarks should clear up this misunderstanding.

In conventional practice, the three fundamental subtractive primaries, cyan (C), magenta (M), and yellow (Y), are typically used as colorants in printing devices. All hues can be reproduced with these colorants, however, black colorant is usually also employed for reasons such as extending the dark portion of the color gamut, improving the rendering of neutrals, and reproducing colors with less CMY colorant to save money and to reduce pile height. Hence, a transformation is needed to convert from the set of fundamental primaries CMY to the larger set CMYK. The inclusion of the neutral colorant K allows one to substitute an amount of K for an equivalent darkness neutral mixture of CMY. Thus, for a given color, some K may be added and some CMY subtracted to produce the same perceived color. This colorant substitution method is known as Gray Component Replacement (GCR) *(See, e.g., R. Bala, "Device characterization," Chapter 5 in Digital Color Imaging Handbook, G. Sharma Ed., CRC Press, 2003.)*

Accordingly, the definition for the term "neutral" in para. 0076 of the Specification comports with the conventional definition – that of the perceived color of an object or colorant. (The Examiner should note that color is a quality that is not so much intrinsic but one that actually occurs upon perception, i.e., it is experienced or perceived.)

Hence, the Examiner should note that the objective in the *conventional* GCR technique is for the grey component replacement to benefit a printed image that will be viewed under white light, and therefore the conventional technique employs black ("K", a "neutral" colorant under many illuminants) as the replacement component for non-neutral colorants such as C, M, Y.

However, the coincidental inclusion of "neutral" in the phrase *"illuminant-neutral gray component replacement (GCR)"* as chosen by the inventors, does not, and is not intended to, refer to simply employing a black colorant as the

replacement component in a conventional GCR technique. The sole use of a black colorant as a replacement component is, as was noted by the Examiner, the typical or *de facto* replacement colorant technique in conventional GCR.

In contrast, *illuminant-neutral gray component replacement (GCR)* is a phrase created by the applicants to refer to a novel GCR technique: that is, to choose the amount and spectral characteristic of one or more replacement component colorants according to the particular combination of the wide band *and narrow band* illuminants that will be applied to the rendered composite image during a variety of viewing situations. And, in doing so, the optimization of the amount and spectral characteristic the replacement component colorant(s) may be determined according to the narrow band illuminant(s) intentionally applied in a controlled illumination environment, in order to improve the recovery one or more source images embedded in the rendered composite image. One factor in this determination is the cross-illuminant-common density, as disclosed in the specification:

> [00177] Whereas a conventional GCR technique uses common density of colorants under a single illuminant (typically ambient white light), a novel form of GCR is contemplated for the encoding and rendering of a composite image, which is described herein as "illuminant-neutral gray component replacement (GCR)", which includes *determination of the common density of the colorants used in rendering the composite image, when the rendered composite images are subjected to one or more of the complementary illuminants*. This specialized consideration of common density is described herein as the "cross-illuminant-common density". *[Emphasis added.]*

Thus, according to the teachings of the invention, when optimizing the system for selective deposition of the colorants on a substrate:

> [00191] Under monochromatic illumination, all colorants, neutral and non-neutral, lead to a neutral perception of density. That is, under sufficiently narrowband illumination, such as red light, an image is perceived as neutral, possessing only a varying degree of darkness, and lacking other color attributes such as hue and chroma. This perception is independent of the colorants employed to construct the image. Gray component replacement in this setting may be accomplished by replacing a given colorant with neutral colorants, non-neutral colorants, or a combination of a plurality of neutral and non-neutral colorants. The *neutrality of the replacement colorant is highly illuminant dependant and we refer to GCR using a colorant that is non-neutral under white light and neutral under the target illuminant as illuminant-neutral GCR.*
> *[Emphasis added.]*

Accordingly, applicants teach the novel aspect that there is a optimal choice among neutral and non-neutral colorants to be employed as the replacement colorant. The optimal choice may be one or another, or a combination of several, in order to optimize the appearance of the rendered composite image. Note that this novel illuminant-neutral GCR technique may be implemented to increase the visual recognition of an embedded source image, or to decrease it. This recognition, or lack thereof, may be tailored to a viewing situation having a wideband illuminant (e.g. white light) or to a viewing situation having one or more narrowband illuminants.

Turning now to USP 6891959 (Reed):

The Examiner's basis for the rejection, as evidenced by the assertion on page 6 of the Office Action (that "Bk colorant used to encode image 10 is the illuminant-neutral GCR") is incorrect. Reed only discloses "combining an inverted watermark signal 'tweak' or 'bump' in a K channel with a corresponding non-inverted watermark signal tweak or bump in the CMY channels..." (C2, L54-57) Note that Reed teaches the "CMY pixels and the K pixels are thus out-of-

phase with respect to one another..." (C4, L38-40.) Accordingly, and with reference to Fig. 1b in Reed, the Examiner will see that each pixel "bump"/"tweak" is applied to each and every one of the CMY channels, and an inverse amount (respectively, a "tweak"/"bump") is applied to the K channel. Thus, the addition of the inverted watermark signal to the K channel in the overall image requires that each and every one of the non-K colorants be adjusted in inverse relationship to the K channel. If not for this inverse compensation, there would not be the disclosed advantage of "greatly reducing visibility of the digital watermark." (C2, L 59-60.)

In essence, Reed merely discloses the artificial injection of a black and white watermark image into an existing image by adjustments to the K signal channel in the existing image. Then, to compensate, the other channels (C, M, Y) in the existing image must be adjusted (but inversely to the K channel).

Because of Reed's scheme to artificially inject the watermark image, one can argue that the approach in Reed may have similarities to under color removal (UCR); however, it does not employ or teach GCR.

Further, with respect to the claimed embodiments, Reed has no disclosure or teaching for the claimed:

> "encoding includes illuminant-neutral gray component replacement (GCR) that employs determination of the common density of the colorants used in rendering the composite image when the rendered composite image is subjected to one or more of the N narrow band illuminants, and wherein the neutrality of the replacement colorant is illuminant dependant, whereby the replacement colorant is non-neutral under white light and neutral under the selected one of the *N* narrow band illuminants."

Accordingly, the Examiner will find that the new claims, which include reference to the above-described illuminant-neutral gray component replacement (GCR), are not anticipated by Reed.

Rejections Under 35 USC 103

Claims 1, 3-30, 32-35, 41-42, and 44-45 were rejected under 35 USC 103(a) as unpatentable over Chew et al. (US 5576528) in view of Bares et al. (6972866). These claims are cancelled. New claims 46-79 are believed patentable for the foregoing reasons applied to the rejection based on Reed. Chew et al. and Bares et al. are distinguishable from the claimed embodiments, as discussed hereinabove. Bares et al. is directed to a method for classifying pixels into neutral and non-neutral categories. Chew et al. discloses aggregation of bar code symbols having bars of differing colors that overlap each other, and encoding and decoding methods for same. These references, alone or in combination, lack any teaching or disclosure of the claimed encoding that employs the illuminant-neutral gray component replacement (GCR) technique.

Conclusion

In the interest of expedited prosecution, applicants have provided the Examiner with clarification of the claimed mapping and encoding features, and now submit new additional claims, all of which claim one or more of the novel encoding features described hereinabove. New claims 46-79 are believed allowable for the foregoing reasons. Support for these claims may be found in the specification as described hereinabove.

Applicants respectfully request that the Examiner withdraw the final rejections and allow claims 46-79.

The undersigned Xerox Corporation attorney hereby authorizes the charging of any necessary fees, other than the issue fee, to Xerox Corporation Deposit Account No. 24-0025.

The Examiner is encouraged to consider a telephone interview to discuss the current amendment, whereby further discussion of the claimed features may be advantageous to the disposition of this case. The Examiner is hereby invited to arrange such an interview by calling Mark Z. Dudley, at telephone number 585-265-7014, in Webster, New York.

Respectfully submitted,

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